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The Development of Ethical Reasoning: A Comparison of Online versus Hybrid Delivery Modes of Ethics Instruction

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Abstract

There is a concerted effort to improve online learning in higher education, including in the domain of engineering ethics. The benefits of online learning include ease in sharing course content, flexibility in the timing of participation, and increased variation in delivery modes for course material. However, the relative effect of online and hybrid participation in terms of developing students' ethical reasoning is largely unknown, and interactive cases and dialogic learning are central to the pedagogy in ethics courses. An opportunity to fill this knowledge gap occurred while testing a new pedagogy for enhancing ethical reasoning among engineering students, which was implemented in a graduate-level course over three offerings in Spring 2014, Summer 2014, and Spring 2015. Of the 29 students enrolled, 11 participated on-campus in a weekly discussion-based class, whereas the remaining 18 students completed the majority of the course online. This multi-phase study presents results from a comparative analysis of the differences in ethical reasoning development and perceptions of course components across two groups as distinguished by the students' mode of participation; the former group we classified as "online" and the latter group as "hybrid". Both groups of students showed substantial gains in their ethical reasoning development, as determined by their pre/post N2 scores on the Engineering Ethical Reasoning Instrument. Furthermore, changes in ethical reasoning were not significantly different when students participated in the online-only versus the hybrid mode. Nonetheless, analysis from post-course surveys indicated that the hybrid group perceived course components more favorably than did their online-only peers. In sum, these results indicate that online ethics interventions can be as impactful in developing ethical reasoning as modes that include an in-class component, although students seem to be more satisfied with ethics education when they have the opportunity for face-to-face, in-class interactions with peers and instructors.

Introduction

There is a concerted effort to improve online learning opportunities in higher education in the United States[1,2], and this has also impacted the domain of ethics education in engineering.[3-5] The benefits of online learning include ease in sharing course content[6], flexibility in the timing of participation[5], and increased variation in delivery modes for course material. Nonetheless, completely online courses can sometimes require a *greater* amount of faculty's time[4] as well as substantial "hidden" costs for both professors[3] and students[7]. However, within the context of engineering, the relative impacts of completely online versus hybrid delivery modes on students' *ethical reasoning development* and *ethics course satisfaction* has been largely unexplored. Online or hybrid courses, which have proven to have a substantial and positive impact on collegiate student learning when compared to traditional modes[1], might sometimes even be more beneficial for students' ethical reasoning development than classroom-only instructional modes.

Bourne et al. suggested that learning effectiveness was one of the five foci driving research on online education, along with "student satisfaction, faculty satisfaction, access, and cost effectiveness."[8] With respect to the effectiveness component, perhaps the most comprehensive comparative exploration of online versus traditional modes of instruction comes from Russell,

who synthesized 355 scholarly articles from numerous domains that distance learning intervention modes (e.g., online, video, radio) to traditional in-class modes. Russell found no significant differences between the two,[2] however, an inspection of the articles included within Russell's database (nosignificantdifference.org; last updated in 2010) using the keyword "ethics" revealed *no* hits. Similarly, the Department of Education's report[1] only included one article focused on ethics[9], which indicates that this is an under-explored area research.

Despite the limited presence of comparative ethics articles within these meta-syntheses, we were able to find a few articles that compared the effectiveness of different modes of ethics education within the context of engineering. For example, Feldhaus and Fox found no significant differences in student performance on an end-of-semester assignment when comparing three intervention modes: namely, traditional lecture, online, and compressed (8 hours/day for one week) formats.[10] Similarly, when comparing "in-seat" and "distance"/online courses, Leitch and Dittfurth found no difference in the two groups' scores on a final exam.[11] Likewise, Reeves and Nadolny utilized virtual worlds to present students with an ethical dilemma, and found that "online" and "on-site" students responded similarly to post-course survey items measuring their perceived importance of the activity.[12] Lastly, Canary et al. found that students who received hybrid forms of instruction, which included "both online and face-to-face instruction", scored significantly higher on post-course measures of ethical reasoning than students who participated in "stand-alone" (e.g., as a separate technical ethics course) or "embedded" (e.g., within an existing course) modes of instruction.[13] There are many more studies that focus on the impact of participation in only one mode (e.g., online, in-class, or hybrid), but few have compared these modes of participation, and we have not identified any studies that specifically compared the ethical reasoning development of online and hybrid students with respect to one another.

Theoretically, one advantage of moving ethics education from in-class modes to online modes of delivery is the ease of replication and dissemination of successful interventions. Furthermore, by developing and disseminating ethics education modules in online modes, faculty without the time, resources, background, or expertise with ethical theories, principles, or processes would not be required to lead the ethics content delivery or dialogues.[4] As Newberry stated, "[T]he underlying student-shaping ethos […] depends largely on the attitude of the faculty toward that material."[14] There is a need to lower the barriers for faculty to incorporate ethical instruction into engineering, thereby enhancing engineering faculty's ability to effectively integrate ethics into their classrooms. A well-designed ethics course or set of modules available for asynchronous delivery and designed to be embedded in existing courses makes this possibility a reality.

Purpose of Ethics Education

The National Academy of Engineers (NAE) has suggested that ethics education is critical in engineering curricula because students need to "possess a working framework upon which high ethical standards and a strong sense of professionalism can be developed."[15] These recommendations implicitly reference motivations previously suggested by Harris Jr. and others,[16] such as "to encourage students to take ethical responsibility seriously" and to "improve ethical judgement." In a different vein, Newberry suggested the purpose of ethics education falls into three broad categories: (a) *emotional engagement* or a "student's desire, on an affective level, to recognize, to care about, and to resolve ethical issues"; (b) *intellectual engagement* or "developing a student's understanding, on an intellectual level, of the principles and application

of moral reasoning and of strategies for grappling with conflict and ambiguity"; and (c) *particular knowledge* or "developing a student's knowledge of, and familiarity with, relevant ethical codes, common ethical issues, and cases of ethical precedent."[14]

Our position is that an effective ethics education within engineering should (a) help students *know how* to be ethical by developing their knowledge of codes alongside their ethical reasoning abilities, and (b) cultivate students' ethos or their *desire to be* ethical by developing specific motivational antecedents and dispositional tendencies. In our previous work, we have posited that reflexive principlism[17-19] is a suitable framework for the knowing how or reasoning component, particularly when the applicability of codes is conflicted or uncertain. Hence, in the intervention described in this study, students learned and utilized the reflexive principlism framework, embedded in a SIRA pedagogical structure[20]. Separately, we have posited that the development of empathic perspective-taking is one key disposition that will support the desire to be ethical component.[21] As Newberry indicated[14] (as did Aristotle long ago), emotional engagement, or the desire or courage to be ethical, may be more challenging to cultivate (especially within a short-time frame such as an academic semester) when compared to inculcating a general knowledge of codes, ethical theories, or principles. Therefore, in this study we focused on the knowing how component, specifically through students' (a) development of ethical reasoning and (b) perceptions of the effectiveness of course components.

Case studies are one of the most common methods of delivering ethics education within engineering[22,23] and case studies can be delivered in traditional lecture modes, completely online, or as a hybrid mode with both in-class and online components. Nonetheless, effectively developing ethical reasoning skills and behaviors requires authentic and accessible problems, as well as some form of interaction with others.[4,24-26] The development of ethical reasoning skills does not happen in isolation but rather through engaged mental processing coupled with dialogic interaction with other learners, where the learner reflects on novel insights and perspectives. We have integrated these considerations into our course design. In the next section, we describe the purpose of this investigation, followed by the course structure.

Research Purpose

This paper presents findings from a comparative analysis of the learning outcomes of engineering students who participated either completely online mode or in a hybrid-mode, which included both online and in-class components. For both learning groups, we utilized the same pedagogy designed to enhance ethical reasoning (the SIRA framework).[20] We implemented this pedagogical framework at the graduate-level and assessed student learning and perceptions over three offerings. Specifically, throughout this study we investigated three research questions:

1. What are the differences in engineering students' **ethical reasoning changes** when their mode of participation includes an in-class discussion-based lecture format compared to being completely restricted to online material delivery and interaction?
2. What are the differences in engineering students' **perceived effectiveness** of an ethics course when participating in a hybrid versus a completely online format?
3. Are there any differences in the correlations between ethical reasoning changes and course perceptions between the hybrid and online groups?

Study Overview

This multiphase research study[27] proceeded in three phases. Phase 1 focused on differences in the development of students' ethical reasoning and included a series of quantitative tests comparing between the online only and hybrid groups' ethical reasoning changes resulting from participating in the respective intervention mode. For this comparison, we utilized two validated instruments to measure ethical reasoning via neo-Kohlbergian schema; the Defining Issues Test-2 or DIT2[28] and the Engineering Ethical Reasoning Instrument or EERI[29] (each instrument is described in more detail later). Phase 2 transitioned to explore and compare students' perceived effectiveness of various course components across the online and hybrid groups. Specifically, in Phase 2 we examined and compared students' responses to an instrument designed to measure their perceived effectiveness of *Scaffolding*, *Interactivity*, and *Reflectivity* components of the course by using the SIRA scales.[20] Lastly, in Phase 3 we used correlation analysis to compare the relationships between ethical reasoning development and the SIRA scale responses for both modes of participation.

Figure 1 provides an overview of these research phases and the analysis methods that we utilized within each. While Phases 1 and 2 do not inform one another, we integrated the data collected throughout these phases in Phase 3.

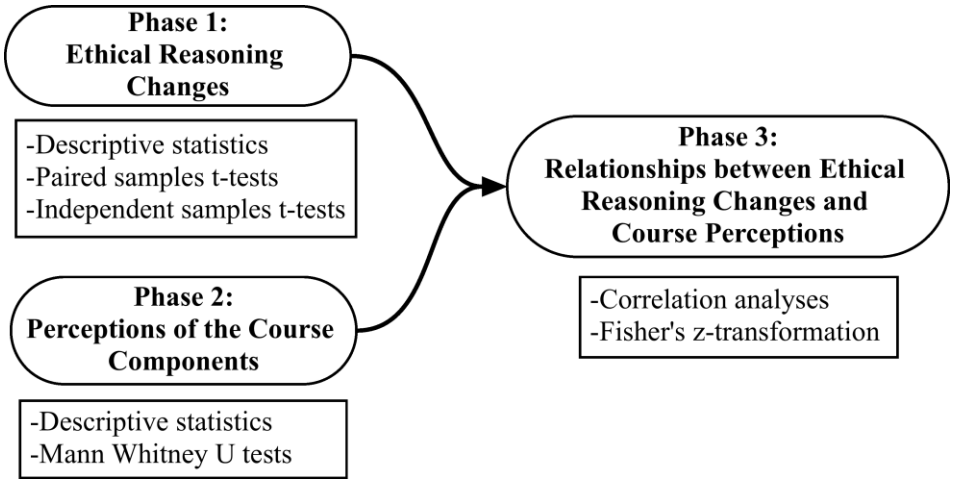

Figure 1: Depiction of the multiphase research process of this study

Intervention/Course Overview

The intervention used in this study began with training students to understand the core philosophy and how to apply the ethical reasoning approach of reflexive principlism[19], which was adapted into engineering ethics from the principlism approach from biomedical ethics.[17,18] The ethics intervention then used a carefully designed pedagogical structure of scaffolding, interactivity, and reflective analysis (SIRA) to guide the students to reason through four engineering ethics case studies.[20] In total, students worked through five online "modules", including a "meta-module" that taught the reflexive principlism approach. A professor with expertise in the respective scholarly domain of each case led the design and delivery of that case. We presented the modules to students in the following sequence:

1. Meta-module: An introduction to reflexive principlism and other ethical theories[19]
2. Case 1: Development of a tissue engineered heart valve for pediatrics[30]
3. Case 2: Kansas City Skywalk Collapse[31]
4. Case 3: Design and distribution of diagnostic devices for bone density[32]
5. Case 4: The Deepwater Horizon oil spill[33]

Students worked through each of the case studies over a three-week (Spring students) or two-week (Summer students) period. Within each case study, students participating in both intervention modes watched videos made by the case's leading professorate, perused readings, worked through a series of mini-quizzes, and responded online to written questions. Additionally, all students completed a group case report to resolve an ethical dilemma pertinent to the respective case. Lastly, all students ended each case with a meta-reflection. For more details on the pedagogical framework, see Kisselburgh et al.[20]

The primary distinction between the two groups we compared in this investigation was that the online students had minimal to no faculty interactions because they did not participate in weekly faculty-led in-class lectures and discussions. Nonetheless, the online students were required to work through the same modular content as the hybrid students and to interact with both hybrid and online peers asynchronously through discussion postings and through their group case reports. Table 1 summarizes the similarities and distinctions between these groups.

Table 1: Distinction between the hybrid and online students' participation

Activity	**Hybrid**	**Online**
Engagement with online content (e.g., case videos, readings)	x	x
Asynchronous discussion posting, reading, and responding	x	x
Participation in a weekly in-class lecture, discussion, and active debate	x	–
Watched a weekly recorded class lecture	–	x
Completion of a group case report at the end of each case study	x	x
Post-case meta-reflection	x	x

Participant Overview

All students in this study participated in one of the three offerings of the same one-credit hour course. Of the 29 total students enrolled in these course offerings, 18 students participated online compared to 11 in the hybrid mode (see Table 2). The majority of the online students were pursuing Master's degrees in online programs whereas the majority of hybrid students were pursuing doctoral degrees in on-campus programs. In the Spring 2014 semester, online and hybrid students interacted with one another either asynchronously through discussion posting or (if they chose) actively through an online social medium such as Google Hangouts or Skype. In contrast, in the Summer 2014 semester all students participated online, and peer interaction was always online. During the Spring 2015 semester, students completed four cases entirely online, along with an additional fifth case that featured an in-class discussion.

Table 2: Overview of participants based on their mode of participation

		Semester			Degree		Sex		Citizenship	
	Total	**Spr14**	**Smr14**	**Spr15**	**MS**	**PhD**	**Female**	**Male**	**U.S. Citizen**	**Non-U.S. Citizen**
Hybrid	11	11	0	0	1	10	2	9	7	4
Online	18	8	5	5	14*	4	7	11	15	3

Note. During the Spring 2015 academic semester, 7 students completed the course but 2 of these students did not complete all of the assessment measures; these students' demographic information was not included in Table 2.
*One student was a post-baccalaureate student, seeking admission to the MS degree program.

Phase 1: Ethical Reasoning Comparisons

Phase 1 included an analysis of the research question, "What are the differences in engineering students' **ethical reasoning changes** when their mode of participation includes an in-class discussion-based lecture format compared to being completely restricted to online material delivery and interaction?" To address this research question, we used two ethical reasoning instruments, as described in the next section.

The Defining Issues Test 2 (DIT2) and Engineering Ethical Reasoning Instrument (EERI)

We tested our first research question by using two validated ethical reasoning instruments: the Defining Issues Test 2 (DIT2)[28] and the Engineering Ethical Reasoning Instrument (EERI)[29]. Both instruments measure ethical reasoning using "neo-Kohlbergian" stages or schema.[34] The "neo" distinction includes the nature of the assessment and the depiction of the stages of moral development. The primary methodological distinction is that instead of using an interview or "production" approach to determine a student's developmental "stage" as did Kohlberg (where no potential responses were provided), the DIT2 and EERI are "recognition tasks" where students rank and rate a pre-defined set of items, prioritizing the responses they feel are most appropriate to a series of ethical dilemmas.[35] Further, neo-Kohlbergian theorists slightly re-defined Kohlberg's stages. Lastly, these theorists preferred the term schema (which suggests an individual has a propensity for a type of thinking that is prompted by pertinent stimuli) rather than stages (which suggest an individual resorts to only a single type of thinking). Table 3 shows the schema as defined by the DIT-2 authors.[36]

The EERI is similar in structure to the DIT2, but prompts students to work through moral dilemmas that are specific to engineering contexts. Zhu et al. defined the schema of moral development measured by the EERI as follows: "preconventional (focusing on personal interest and encompassing Kohlberg's stages 2 and 3), conventional (maintaining norms, equivalent to Kohlberg's stage 4), and postconventional (perspective-taking, ability to appeal to ideals that are shareable and non- exclusive, and expectations for full reciprocity between laws and the individual, which aligns with Kohlberg's stages 5 and 6)."[29] For this study, we used both the DIT2 and EERI, because the EERI provides an engineering-specific instrument, and the DIT2 is more broadly recognizable and utilized.

Table 3: Ethical reasoning schema progression as defined in the Defining Issues Test-2 Guide[36]

Personal Interest Schema	
Stage 2	Focus is on the direct advantages to the actor and on the fairness of simple exchanges of favor for favor
Stage 3	Focus is on the good or evil intentions of the parties, on the party's concern for maintaining friendships and good relationships, and maintaining approval
Maintaining Norms Schema	
Stage 4	Focus is on maintaining the existing legal system, maintaining existing roles, and maintaining a formal organizational structure.
Postconventional Schema	
Stage 5	Focus is on organizing a society by appealing to consensus-producing procedures (such as abiding by majority vote), insisting on due process (giving everyone his day in court), and safeguarding minimal basic rights
Stage 5B/6	Focus is on organizing social arrangements and relationships in terms of intuitively appealing ideas.

We analyzed two statistics from each instrument: the *P score* and *N2 score*. The *P score* measures a student's preference towards post-conventional thinking (i.e., Stages 5 and 6), and the *N2 score* measures a student's preference towards post-conventional thinking *and* the degree to which personal interest schema or pre-conventional thinking (i.e., Stages 1 and 2) is absent.

Comparability of the Groups

In order to compare the differences between the online and hybrid groups with respect to the DIT2 and EERI instruments, we evaluated whether students' responses were comparable at the start of the course. Results from Levene's test for the equality of variances[37] indicated that there was homogeneity of the variances between the online and hybrid students' ethical reasoning scores (i.e., their N2 and P scores on the EERI and DIT2) at the start of the course. Similarly, results from the t-test for differences of means indicated that the means of the two groups were approximately equal at the start of the course. Table 4 shows these results.

Table 4: Comparing variances and means between online and hybrid students' pre-scores

Test	**Difference Score**	**Levene's Statistic**		**t-test for equality of means**			
		F	**Sig.**	**t-stat**	**Sig.**	**Mean difference**	**Std. error**
EERI	**N2**	0.15	.71	1.06	.30	6.33	5.99
	p	1.18	.29	0.65	.52	4.17	6.45
DIT2	**N2**	0.20	.66	0.20	.85	1.11	5.64
	p	0.72	.40	0.20	.84	1.36	7.00

Descriptive Statistics

Next, we calculated the descriptive statistics of students' pre- and post-course scores on the EERI and DIT2 for both groups. Table 5 presents these statistics, and Figure 2 provides a graphical depiction to highlight the relation and variation of responses along each measure and across each group. As the results indicate, online students outperformed hybrid students on every measure, both pre- and post-course. However, as the standard deviations indicate, there was wide variation within both groups on the N2 and P scores of the EERI and DIT2 assessments.

Table 5: Descriptive statistics of students' pre- and post- ethical reasoning scores by group

Group	Statistic	EERI				DIT2			
		N2		P		N2		P	
		pre	post	pre	post	pre	post	pre	post
Hybrid	**Mean**	38.4	55.1	39.8	53.9	43.6	41.1	40.8	39.0
	Std. Deviation	14.8	11.8	14.8	14.8	15.8	16.7	16.3	17.4
Online	**Mean**	46.1	55.7	45.2	51.4	45.1	44.9	43.0	44.1
	Std. Deviation	16.2	20.5	18.0	23.1	14.6	15.3	18.5	18.3

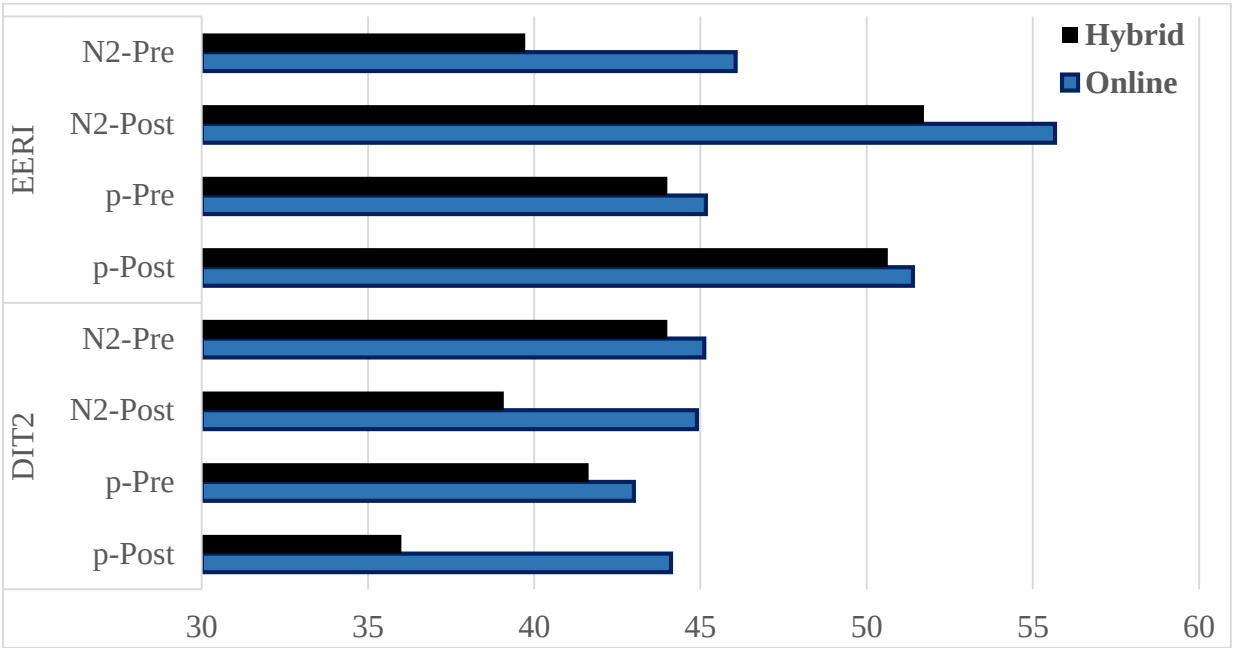

Figure 2: Mean N2 and P scores on the EERI and DIT2 tests for online and hybrid students

Normality of the Difference Scores by Group

To determine whether performing paired samples *t*-tests was a valid methodological approach, we calculated the Shapiro-Wilk statistics for the difference scores for each group.[38] As Table 6 shows, all EERI and DIT2 difference scores were approximately normal.

Table 6: Shapiro-Wilks Coefficients for the difference scores by group

		Hybrid		Online	
		Statistic	Sig.	Statistic	Sig.
EERI	**N2 difference score**	0.97	0.86	0.95	0.40
	P difference score	0.96	0.77	0.95	0.39
DIT2	**N2 difference score**	0.91	0.26	0.92	0.15
	P difference score	0.91	0.27	0.97	0.73

Ethical Reasoning Gains by Group

In order to test the impact of each mode of participation on students' ethical reasoning changes, we conducted a series of paired samples *t*-tests. For each test, the null hypothesis was that students' difference scores on each of the EERI and DIT2 measures would not be significantly different from zero. The alternative hypothesis was that, for each group, differences between the pre and post scores would be significantly greater than zero.

As the results in Table 7 indicate, the hybrid students' EERI N2 and P scores increased on average by 12.0 ($p < .05$; $d = .54$) and 9.6 ($d = .41$) points, respectively; in contrast, the online students' EERI N2 and P scores increased by 9.6 ($p < .05$; $d = .50$) and 6.2 ($d = .29$) points, respectively. Neither group showed substantial increases on the DIT2 measures. Rather, three out of the four of these difference scores were slightly negative (the exception being online students' DIT2 P score). These findings indicate that both groups showed significant improvements on the EERI N2 scores, which evaluated students' preference for post-conventional reasoning alongside their rejection of pre-conventional reasoning when working through engineering-specific ethical dilemmas. While not statistically significant, changes in the hybrid students' EERI P score, which evaluated students' preference towards post-conventional reasoning only, was found to exceed Cohen's convention for a medium effect size ($d = .41$). This change among online students, although lower, was also moderate ($d = 0.29$).[39]

Table 7: Independent samples t-tests for hybrid and online groups

Group	Diff.	EERI					DIT2				
	Score	**Mean**	**STDEV**	**t-stat**	**Sig.**	***d***	**Mean**	**STDEV**	**t-stat**	**Sig.**	***d***
Hybrid	N2	12.0	22.5	1.77	.05*	.54	-4.9	12.7	-1.28	-	-
	P	9.6	23.7	1.35	.10	.41	-5.6	16.6	-1.13	-	-
Online	N2	9.6	19.1	2.13	.02*	.50	-0.2	13.0	-.05	-	-
	P	6.2	21.7	1.22	.12	.29	1.1	15.9	.30	.385	.07

**With a one-tailed t-test, the difference score was significant at the 99% confidence level ($p < .01$)*

Comparing Ethical Reasoning Gains

Next, we tested whether the *difference scores* between the hybrid and online groups were significantly different. Levene's test for equality of variances[37] indicated that there was homogeneity of variances between both groups' difference scores on each measure. As the results of the t-test for equality of means indicated (see Table 8), there were no significant differences in ethical reasoning changes when comparing between the two groups on either of the EERI or the DIT2 measures.

Table 8: Comparing variances and means between online and hybrid students' difference scores

		Levene's Statistic		t-test for equality of means			
Test	**Statistic**	**F**	**Sig.**	**t-stat**	**Sig.**	**Mean diff.**	**Std. error**
EERI	N2	0.15	.71	.31	.76	2.39	7.82
	p	0.06	.80	.40	.69	4.17	8.60
DIT2	N2	0.07	.80	.95	.35	4.65	4.91
	p	0.02	.90	.95	.28	6.75	6.18

Phase 2: Perceived Effectiveness of Course Components

In Phase 2, we explored the research question, "What are the differences in engineering students' **perceived effectiveness** of an ethics course when participating in a hybrid format versus a completely online format?" To address this research question, we evaluated students' perceived effectiveness of the course components related to *Interactivity*, *Reflectivity*, and *Scaffolding* as measured by three SIRA scales.[20] Our operational definition of the SIRA scales are as follows:

- Interactivity Scale: Perceived effectiveness of course components that involve interactions (e.g., class discussions, online posting, reading/responding to peers' posts)
- Reflectivity Scale: Perceived effectiveness of course components that involve prompted ethical considerations and reflection on this thinking in a formalized manner
- Scaffolding Scale: Perceived effectiveness of course components that involve structured thinking (e.g., quizzes, directions on materials, assignments, instructor feedback)

Development and Reliability of the SIRA Scales

We designed a series of questions to gauge students' perceived effectiveness of these course components. The SIRA scales included 14 items, each set on a 5-point Likert-type scale, where students indicated their level of agreement towards each item (responses ranged from 1 = Strongly Disagree to 5 = Strongly Agree). Cronbach's alpha was calculated for each scale, and indicated that internal reliability for the Interactivity ($\alpha = .733$) and Scaffolding ($\alpha = .832$) scales were acceptable, whereas the Reflectivity ($\alpha = .631$) scale was minimally acceptable.[40] Lastly, we created an aggregate index score for each SIRA scale by averaging the item responses.

Descriptive Statistics

Table 9 shows the mean responses to the SIRA items and scales by intervention mode. The means indicated that the hybrid students were more favorable than were the online students in all but one of the scale items. The item with the largest difference between the groups was, "My opportunities to participate in discussions were sufficient," as the average response among hybrid students ($\mu = 4.45$) was more than 20% higher than the average response among online students ($\mu = 3.33$). Conversely, online students ($\mu = 3.89$) responded more favorably than hybrid students ($\mu = 3.73$) on the question, "I read many of the postings of my fellow students (on the blogs)." As the hybrid students responded more favorably to nearly every item, these students' responses to each of the aggregated SIRA scales were also higher.

Table 9: Overview of hybrid and online students' responses to the SIRA items and scales

SCALE & Scale items	**Hybrid**		**Online**	
	Mean	**STDEV**	**Mean**	**STDEV**
INTERACTIVITY (α = .73)	**4.36**	**0.34**	**3.64**	**0.72**
My opportunities to participate in discussions were sufficient.	4.45	0.52	3.33	1.57
Hearing the opinions of others helped my general learning of ethics.	4.45	0.52	4.11	0.68
The discussions led by the instructors help my learning of ethics.	4.36	0.50	3.83	0.86
The feedback I receive from my classmates helps my learning of ethics.	4.18	0.40	3.28	0.75
REFLECTIVITY (α = .63)	**4.21**	**0.48**	**4.04**	**0.64**
Reading the postings of my peers helps me to see a different perspective.	4.45	0.52	4.11	0.76
Seeing the class discussions helped me to see different perspectives.	4.45	0.69	4.11	0.76
I read many of the postings of my fellow students (on the blogs).	3.73	0.79	3.89	0.90
SCAFFOLDING (α = .83)	**4.07**	**0.39**	**3.87**	**0.61**
When I had questions about the course, I was able to find the support or feedback that I need from the instructors.	4.18	0.40	4.17	0.71
The structure and presentation of the materials helped to guide my development of ethical reasoning.	4.18	0.40	3.83	0.79
When the material was challenging, I was able to find the support or feedback that I need from the instructors.	4.09	0.70	3.89	0.68
When I had questions about the cases, I was able to find the resources I needed on the OpenClass system.	4.00	0.45	3.78	0.94
When the material was challenging, I was able to find the resources I needed on the OpenClass system.	3.91	0.54	3.67	0.84

Note: Responses were along a 5-point Likert-type scale where students indicated their level of agreement towards each item, where 1 = Strongly Disagree and 5 = Strongly Agree

Comparing SIRA Scale Responses by Group

In order to test whether students' perceived effectiveness of the Interactivity, Reflectivity, or Scaffolding course components were distinct between the hybrid and online groups, and as the online students' Interactivity responses ($W = .890$, $p < .05$) and hybrid students' Scaffolding responses ($W = .861$, $p < .05$) were approximately non-normal, we conducted three Mann-Whitney U tests (the non-parametric alternative to the independent samples t-test).[41] As the distributions of the SIRA scale responses had different shapes – as evident by examining the histograms of each – in each test we compared mean ranks rather than medians.

The three Mann-Whitney U tests indicated (a) Interactivity responses were greater for the hybrid students (*Mean rank* = 20.50) than for the online students (*Mean rank* = 11.64), U = 38.5, $p = .005$; (b) Reflectivity responses were not significantly different between the hybrid students (*Mean rank* = 17.86) and online students (*Mean rank* = 13.25), U = 67.5, $p = .159$; and (c) Scaffolding responses were not significantly different between the hybrid students (Mean rank = 16.86) and online students (*Mean rank* = 13.86), U = 78.5, p = .363. This analysis indicated that only the Interactivity scale responses were significantly different between the groups.

Phase 3: Relationships between Ethical Reasoning Changes and Course Perceptions

In Phase 3, we integrated data from Phases 1 and 2 to address the research question, "Are there any distinctions in the correlations between ethical reasoning changes and perceptions of the course effectiveness when comparing between hybrid and online groups?" We computed Pearson product-moment correlation coefficients to assess the relationship between the DIT2 and EERI *P* and *N2 difference scores* and students' responses to the SIRA scales. Specifically, we conducted these analyses separately for the hybrid and online groups and then we compared these correlations.

Relationships between Ethical Reasoning Changes and the SIRA Scales

Using a .01 level of significance, no correlations were found to be statistically significant. For the hybrid students, there were positive correlations between each of the SIRA scales and each of the DIT2 and EERI difference scores. The correlations between the hybrid students' Reflectivity responses and the EERI P score, DIT2 N2 score, and DIT2 P score indicated a large effect size (i.e., Pearson's *r* was greater than .50). These students' Reflectivity responses and the EERI N2 score showed a medium effect size (i.e., Pearson's *r* was greater than .30).[39] Likewise, for the hybrid group, several other correlations were above the threshold for a small effect size (i.e., Pearson's *r* greater than .10; see Table 10).

Conversely, there was a negative correlation between the online group's Interactivity and Reflectivity scale responses and their EERI difference scores. As a result, the correlations between ethical reasoning difference scores and the Interactivity and Reflectivity scale responses were higher for the hybrid group than the online group for all scores, whereas correlations between the Scaffolding scale responses and the ethical reasoning difference scores were higher for the online students (the one exception was the DIT2 N2 difference score, where Pearson's $r = 0.13$ for both groups).

Table 10: Correlations between the SIRA scales and the EERI/DIT2 difference scores by group

		Interactivity		Reflectivity		Scaffolding	
		Hybrid	**Online**	**Hybrid**	**Online**	**Hybrid**	**Online**
EERI	**N2 diff. score**	0.09	-0.10	0.48	-0.01	0.09	0.26
	P diff. score	0.16	-0.17	0.55	-0.03	0.11	0.29
DIT2	**N2 diff. score**	0.25	0.12	0.58	.16	0.13	0.13
	P diff. score	0.23	0.06	0.60	.18	0.05	0.17

In terms of ethical reasoning development, Table 10 indicates that all SIRA components positively contributed to the hybrid group's development, the scaffolding components positively contributed to the online groups' development, and there was a vacillating influence of the interactivity and reflectivity components on the online students' development.

Next, To determine whether these independent correlations were significantly different between the groups, we conducted a Fisher's z-transformation[42,43]. This test takes into account Pearson's product moment correlation as well as the sample size of each group. This analysis indicated there were no significant differences in the relationships between ethical reasoning and the SIRA scale responses when comparing between the online and hybrid groups (see Table 11).

Table 11: Comparing correlations between online and hybrid groups

		Interactivity		***Reflectivity***		***Scaffolding***	
		z	**p**	**z**	**p**	**z**	**p**
EERI	**N2 difference score**	0.44	0.66	1.23	0.22	0.40	0.69
	P difference score	0.22	0.45	1.49	0.07	0.43	0.67
DIT2	**N2 difference score**	0.31	0.76	1.12	0.26	0.00	1.00
	P difference score	0.40	0.69	1.15	0.25	0.28	0.78

Discussion

In this multi-phase investigation, we compared how two separate modes of participation in an engineering ethics course affected (a) students' ethical reasoning development, (b) students' perceived effectiveness of an engineering ethics course, and (c) correlations between each of these measures. The comparative variable centered on the mode in which each group participated; we characterized one group as hybrid and the other as online. The defining distinction between the two groups was that the former participated in a weekly, in-class, face-to-face discussion-based class whereas the latter did not (although the on-line only group had the opportunity to watch a recording of the classroom discussion).

Phase 1 results indicated that when compared to one another, the hybrid and online students did not have significantly different developmental gains, as measured by two different ethical reasoning instruments, the DIT2[28] and EERI[29]. Nonetheless, both groups showed an increased affinity towards post-conventional thinking (as defined by neo-Kohlbergian theorists) paired with a reduction in pre-conventional thinking when responding to engineering specific ethical

dilemmas, as measured by the EERI.[44] However, the pre/post results from the DIT2, an instrument not specific to engineering, did not indicate significant developmental gains for either group. Nonetheless, an examination of the effect sizes across groups indicated that the EERI changes were slightly more positive for the hybrid group than the online only group.

These findings are supported by a limited body of research in ethics education that compares students' learning outcomes between these two modes of delivery[10-12]. For example, Canary et al.[13] found that students participating in a hybrid group – which included "both online and face-to-face instruction" – outperformed both "stand-alone" and "embedded" groups in terms of their "knowledge of relevant standards." Furthermore, these scholars did not find differences in each group's post-course levels of ethical reasoning as measured by the Engineering and Science Issues Test[45] (a similar measure to the EERI used in this study). Likewise, our findings are supported by a meta-analysis conducted by the U.S. Department of Education, who found, "Effect sizes were larger for studies in which the online instruction was collaborative or instructor-directed than in those studies where online learners worked independently."[1]

Although we did not find differences in the ethical reasoning changes between the two groups of students, during Phase 2, several surprising insights arose when comparing the online and hybrid groups' perceived effectiveness of course components as measured by the SIRA scales.[20] For example, students who participated in the hybrid mode were generally more favorable towards all of the Interactivity, Reflectivity, and Scaffolding course components than their online-only peers were. However, the only significant difference we found between the students' SIRA Scale responses was that the hybrid students' responses to the Interactivity scale were more favorable.

Lastly, in Phase 3, we did not find any of the correlations between ethical reasoning development and the SIRA scales to be significantly different when comparing these correlations between the hybrid and online groups. However, the effect sizes of the Reflectivity correlations indicated that this component was particularly critical for hybrid students' ethical reasoning development. While online students did not score significantly higher along the scaffolding items, correlations suggested that Scaffolding components were more beneficial for these students' ethical reasoning development. We did not find any significant differences in correlations across groups.

Despite finding no significant correlations between the online students' interactivity and reflectivity scale responses in relation to their ethical reasoning development, on average, the online students responded positively to each of the SIRA scales. Hence, we posit that these course components were beneficial for students in some way, an assertion we will need to investigate in the future.

While the ethics modules we have developed do not represent a "MOOC", as they were not "massively open", the findings inform the potential for pursuing MOOCs in the domain of ethics education in the future. Specifically, in order for an online ethics course to be engaging, it may need to encourage (or possibly require) the sharing of perspectives between participants. Further, sharing perspectives may be more engaging for students' when it is face-to-face. Many students who successfully complete MOOCs tend to find a support group or online community, so this "extra" component might simultaneously bolster completion rates for a MOOC-like ethics course, particularly by reducing students' "feelings of isolation" and "lack of interactivity."[7]

Limitations

Within this study, the sample sizes utilized were small and, therefore, the statistical power of several of the analyses was below the .80 suggested threshold from Cohen[39]. We need to conduct future investigations, particularly those with higher sample sizes which utilize similar pedagogical frameworks, in order to support the findings reported herein.

Conclusion

In light of growing trends toward online delivery of ethics instruction, the findings from this study can inform future improvements in engineering ethics instruction by identifying strategies for elucidating the differences in online participation when compared to in-class or hybrid participation. Specifically, this study revealed several important distinctions in the participation, engagement, and success of students who enrolled in an engineering ethics course in online only versus hybrid modes of participation, and differences in the ways in which these groups of students perceived the value and importance of various course components. The results indicated that a well-designed online course, with sufficient scaffolding and reflectivity and at least some interactivity, has a comparable influence on students' ethical reasoning development whether they participate online or in a hybrid format. However, facilitated discussions seemed to improve student satisfaction, as evident by the hybrid groups' positive feedback to the SIRA scales when compared to their online-only peers. Hence, with this caveat in mind, our findings optimistically support the transferability of this ethics educational intervention (and others that are similar in nature) to online learning environments, although we would emphasize that we need to conduct future investigations in order to bolster this suggestion.

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